EXHIBIT 11

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By controlling switch 429 and demodulators 416, master controller 415 determines which of the signals input to amplifiers 408 are "collected," i.e. output from one of demodulators 416. Note that switch 429, because it follows the design of switch 462a, can simultaneously connect the output of every amplifier 408 to any number of demodulators 416. This is important if the signal provided by one of amplifiers 408 includes more than one independent signal. For example, if the energy output by amplifier 408b includes two adjacent 6 Mhz NTSC video signals between 6–18 Mhz, and the output of amplifier 408b can be switched to both demodulators 416b and 416c, both video signals can be "collected." Note that none of demodulators 416 can receive the output of more than one of amplifiers 408, even if the two output signals do not overlap in frequency. Such switching would not make sense because demodulators 416 select only one signal at a time.

As described earlier, modulators 428 implement the first step in applying the outputs of demodulators 416 to communication line 402. Specifically, each of modulators 428 receives the single basebanded signal output by the corresponding one of demodulators 416. As shown in FIG. 6a, the process includes mixing the frequency of a local oscillator (l.o.) with that of the input signal, and filtering the output. This process creates a new signal, with identical information content, within an RF frequency band.

The local oscillators used by each of the modulators 428 are such that the resulting output frequency bands do not overlap. This allows the outputs to be combined onto a single conductive path. In a preferred embodiment, the frequency bands confining the outputs of modulators 428 are adjacent in addition to being non-overlapping. This minimizes the width of the band occupied by the combined signal.

The signals output by modulators 428 are all transmitted to coupler 428'. That component combines the individual signals onto a single conductive path, and passes it to interface 409. That component applies the combined signal onto communication line 402, as described above.

4) Control Signal Processing (FIG. 7)

Referring to FIG. 7, processor 420 includes filters 427a–427c and 427z (collectively, filters 427), demodulators 443a–443c and 443z (collectively, demodulators 443), and digitizer 436.

As described above, control signals generated by individual control devices 493 and targeted for master controller 415 are transmitted onto local networks 411 by video receivers 419, received by interfaces 404, and fed to extended pairs 405. The control signals are recovered from extended pairs 405 by signal separators 413 and routed to control signal processor 420 along paths 477, which have a one-to-one correspondence with signal separators 413. The control signals arrive at processor 420 at the frequency and waveform at which they were fed to extended pairs 405.

Control signals from communication line 402 also transmit to processor 420. These signals are transmitted from signal distribution system 403 along path 420b (FIG. 4).

As seen in FIG. 6, path 420b connects to filter 427z, while signals transmitting over paths 477 present at corresponding filters 427a–427c. Filters 427 restrict the frequency of the signals passing to the corresponding demodulators 443 to the bands used by the control signals targeted for master controller 415. Signals passing through filter 427z are received by demodulator 443z, while signals passing through filters 427a–427c are received by demodulators 443a–443c.

Demodulators 443a–443c and 443z convert such received signals to baseband frequencies, and pass the results to

digitizer 436. That device converts the basebanded signals to digital signals, and passes them to master controller 415 over path 420a. Common methods for communicating digital information between two components on a circuit board can suffice for this link. Methods of digitizing and communicating control signals originating from infrared transmitters are described in detail in the second CIP application.

5) EXAMPLE #1

Referring to FIGS. 1a, 2, 4, 4a, 5a, 6a, and 7, the following is an example of the processing of non-telephone signals in transceiver/switch 400. Assume that line 402 is a fiber optic cable transmitting high frequency optical impulses that represent frequency modulated encoding of a group of signals with a bandwidth of 5,000 Mhz. Among the individual signals expressed in the 5,000 Mhz band are 50 standard amplitude modulated NTSC signals confined within adjacent 6 Mhz channels. These are expressed between the frequencies of 2000 Mhz and 2300 Mhz.

One of the functions of the communication system of this invention is to transmit any of the individual signals expressed between 2000–2500 Mhz on demand to video receivers 419 and transceiver 491c connected to local networks 411a–411c. Furthermore, the system must allow the users to indicate their video selections by using infrared remote control transmitters 493a, 493b, and 493c shown in FIG. 1a.

Communication line 402 also accommodates communication of signals in the opposite direction, away from transceiver/switch 400. A second task of the communication system is to allow video transmitters 417 and transceiver 491c to transmit signals onto line 402.

The light impulses from communication line 402 are received by interface 409. That component responds to these impulses by producing a frequency demodulated electrical version of the 5000 Mhz signal encoded therein. Block converter 423 in interface 409a selects the frequencies between 2000 Mhz and 2500 Mhz, and converts them to voltage variations between 100 Mhz and 600 Mhz.

The 500 Mhz wide, composite electrical signal provided by interface 409 is transmitted to splitter 426' in signal distribution subsystem 403a. Splitter 426' splits the input energy four ways, transmitting the signal to demodulators 426 and also along path 420b to control signal processor 420.

Referring also to FIG. 8, demodulators 426 react in the following manner. In response to signals fed from master controller 415 over link 446a, demodulator 426a selects and basebands the signal between 176 Mhz and 182 Mhz (video signal U). Similarly, demodulator 426b selects and basebands the 6 Mhz AM signal between 188–194 Mhz (video signal V), and demodulator 426c selects the signal between 200–212 Mhz, which is a digital signal conforming to the "10BaseT Ethernet" standard (digital signal Y), and converts it to a demodulated signal at baseband. Thus, two ordinary NTSC video signals are selected from line 402, basebanded, and provided to switch 462a along two separate conductive paths. A third conductive path provides a 12 Mhz wide computer signal.

Switch 462a applies the output of demodulator 426a (video signal U) onto the path leading to modulator 410a, the output of demodulator 426b (video signal V) onto the paths leading to modulators 410b and 410d, and the output of demodulator 426c (digital signal Y) onto the path leading to modulator 410c.

Modulators 410 modulate their input signals, converting them to frequency bands between 1 Mhz and 22 Mhz. These

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.are the frequencies used to transmit signals from transceiver/ switch 400 to local networks 411. Specifically, modulators 410a and 410b amplitude modulate video signals U and V, respectively, to produce RF signals at 40 dB mV between 1–6 Mhz in each case. (The frequency band between 1 and 6 Mhz can be used to provide a standard 6 Mhz NTSC channel if the part of the lower vestigial sideband between 0–1 Mhz is filtered out. This technique is described in the second CIP application.) Modulator 410d, on the other hand, converts video signal V to an FM signal at 40 dB mV between 7 and 22 Mhz, and modulator 410c converts digital signal Y to a signal confined between 6 and 18 Mhz. Switch 401 receives the outputs of modulators 410a–410c and applies them to paths 478a–478c, respectively. Switch 401 also applies the output of modulator 410d to path 478a and couples the output of modulator 410b onto path 478c. Thus, path 478a conducts both video signal U and video signal V (in different frequency bands), path 478b conducts video signal V, and path 478c conducts both video signal V and digital signal Y (in different frequency bands).

The signals applied to paths 478a–478c transmit to signal separators 413a–413c, respectively. Those components feed the signals onto extended pairs 405a–405c, respectively, using techniques described below.

The signals transmit across pairs 405a–405c to local network interfaces 404a–404c, respectively, each of which converts the signals as necessary to enable them to be transmitted over respective local networks 411a–411c. Specifically, local network interface 404a converts video signal V to an AM signal in the frequency band between 24–30 Mhz and video signal U in the frequency band between 12–18 Mhz. Meanwhile, local network interface 404b converts video signal V to an AM signal in the frequency band between 54–60 Mhz (corresponding to VHF channel 2). Finally, local network interface 404c converts video signal V to the AM signal between 12–18 Mhz, and expresses digital signal Y between the frequencies of 18–40 Mhz. Techniques to perform these conversions are described below.

After this conversion, local network interfaces 404 amplify the signals and retransmit them onto the respective local networks 411. Once applied to local networks 411, signals U, V, and Y are received by video receivers 419 and transceiver 491c. Video receivers 419 convert signals V and U to tunable frequencies before transmitting them to connected televisions 492, and transceiver 491c converts its signal to a form appropriate for computer 495c. Video receivers 419a and 419a', in particular, apply a single upshift of 186 Mhz to energy between the frequencies of 12 Mhz and 30 Mhz, converting signals U and V to video signals with picture carriers at 199.25 and 211.25 Mhz, (i.e. VHF channels 11 and 13), respectively. A design for a video receiver that performs such a block conversion is given in the second CIP application, and a design for transceiver 491c is given in the first CIP application. These conversions allow users at local networks 411a and 411b to watch video signal V, those at local network 411a can also watch video signal U, and computer 495c at local network 411c can receive digital signal Y, which is an "EtherNet" signal from communication line 402.

Meanwhile, RF transmitters 417 connected to local networks 411 apply signals to those networks that transmit in the opposite direction. These are received by interfaces 404, which in turn apply them to pairs 405. The signals then transmit to signal separators 413 in transceiver/switch 400. Those components direct the signals along paths 479 to amplifiers 408 in collection subsystem 407a of processor

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418. All of these signals transmit across extended pairs 405 at frequencies between 24 and 100 Mhz, a band that does not overlap with the band in which signals transmit in the opposite direction (i.e., 1 Mhz–22 Mhz).

(Techniques embodied in local networks interfaces 404 that receive signals from local networks 411, convert them, and transmit them across extended pairs 405 are described below. The routing of these signals by signal separators 413 is also described below.)

An example of the signals transmitted by the RF transmitters 417 connected to local networks 411 and the conversions performed by local network interfaces 404 follows. Assume that video transmitter 417b inputs an NTSC video signal (video signal W) from camera 494b and feeds it onto local network 411b amplitude modulated between 6–12 Mhz. This signal is received by local network interface 404b, converted to an FM signal between 24–54 Mhz, amplified, and applied to extended pair 405b. At transceiver/ switch 400, video signal W transmits to signal separator 413b, which applies it to amplifier 408b. Meanwhile, video signal X is generated by camera 494c and transmits from video transmitter 417c to amplifier 408c in an identical manner (via interface 404c, extended pair 405c, and signal separator 413c).

Transceiver 491c, meanwhile, receives a digital signal from computer 495c. That signal carries 1 Mbits/sec of information, (less than digital signal Y) and is called digital signal Z. Transceiver 491c expresses this signal between 1–6 Mhz, and applies it to local network 411c where it is intercepted by local network interface 404c. Interface 404c encodes this signal using frequencies between 54–100 Mhz and transmits it onto extended pair 405c. The signal transmits across to transceiver/switch 400. Because it is expressed at relatively high frequencies, signal Z is received with a lower SNR, but its wider bandwidth allows reception with a low error rate. At transceiver/switch 400, digital signal Z transmits through signal separator 413c to amplifier 408c.

The signal reaching amplifier 408c covers the frequencies between 24 Mhz to 100 Mhz and includes both video signal X and digital signal Z from local network 411c. Under instructions from master controller 415, switch 429 directs the output of amplifier 408c to both of demodulators 416b and 416c. Meanwhile, video signal W reaches amplifier 408b. Upon output from amplifier 408b, switch 429 directs that signal to demodulator 416a.

Under the control of controller 415, each demodulator 416b, 416c processes only one of the two individual signals that constitute their inputs. Specifically, demodulator 416b demodulates video signal X, providing it at baseband frequencies to modulator 428b, while processor 416c demodulates digital signal Z, providing it at baseband frequencies to modulator 428c. Processor 416a, meanwhile, demodulates video signal W, providing it at baseband frequencies to modulator 428a.

(These signals also transmit along paths 488. Because signal distribution subsystem 403a is not equipped to input signals from these paths, however, signals transmitting along paths 488 are not received.)

Modulators 428 convert their inputs to RF frequencies. Specifically, modulator 428a converts video signal W to a modulated form between 400–406 Mhz. Similarly, modulator 428b converts video signal X to a modulated form between the frequencies of 406–412 Mhz, and modulator 428c converts digital signal Z to a modulated form between the frequencies of 412–424 Mhz.

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These three signals are fed to coupler 428'. That component combines the three signals and transmits them to interface 409. Interface 409 then encodes the energy between 400-424 Mhz in this input signal into light impulses which it applies to communication line 402.

Control signals are also transmitted from local networks 411 to transceiver/switch 400. At local networks 411a, control signal A is introduced by IR remote control transmitter 493a in the form of light patterns. These are detected by video receiver 419a, converted to an electrical signal with a 0.5 Mhz bandwidth centered at 23 Mhz, and fed onto local network 411a. Control signal A is then intercepted by local network interface 404a and fed onto extended pair 405a between the frequencies of 22.75-23.25 Mhz. It transmits to transceiver switch 400, passing through signal separator 413a to paths 479a and 477a. Path 479a leads to amplifier 408a. Although this path may connect to one of demodulators 416, control signal A will transmit no further because demodulators 416 do not demodulate signals in the band between 22.75-23.25 Mhz.

Control signal A transmits across path 477a through filter 427a to demodulator 443a in control signal processor 428 (FIG. 7). That component basebands the signal, passing it to digitizer 434 which converts the signal to digital form. Finally, this digital representation of control signal A is transmitted to master controller 415. Control signals B and C are created by IR remote control transmitters 493b and 493c and transmit to master controller 415 in a similar manner using the same frequencies.

Following is an example of a change in channel selection. As explained above, video signal U is part of the 5000 Mhz signal transmitting on line 402. Specifically, assume that video signal U spans the frequencies between 2076 Mhz and 2082 Mhz, which are translated by interface 409 to the band between 176-182 Mhz. This band is selected when demodulator 426a converts it to the "intermediate" frequency. In response to a control signal from local network 411a, however, master controller 415 can instruct demodulator 426a to demodulate a different channel, such as the one between 182 Mhz and 188 Mhz, thereby "assigning" a new channel to video signal U.

FIG. 8 shows a table which summarizes the signals, transmission direction, and channels used for the communication described in this example.

G. Transmitting Signals from One Local Network to a Second Local Network (FIGS. 1b, 5b)

Signal distribution subsystem 403b, an alternative embodiment of signal distribution subsystem 403, is shown in FIG. 5b. There are only two differences between this embodiment and that of subsystem 403a. One is that switch 462b replaces switch 462a. The second difference is that signals from signal collection subsystem 407a (FIG. 6a) transmit at baseband along paths 488 to switch 462b, providing four extra inputs to that switch. Thus, switch 462b can (under the direction of master controller 415 via link 446b) provide signals recovered from local networks 411, in addition to signals provided from communication line 402, to modulators 410. This allows communication between the local networks 411.

Following is an example of communication conducted by a system that includes signal distribution subsystem 403b. Referring to FIG. 1b, a private telephone network connecting offices 512a–512e (collectively, offices 512) is established by PBX ("private branch exchange") 500 and extended pairs 405a–405e that connect between each office and PBX 500. PBX 500, which is located in wiring closet 501, also connects to local exchange 475 (i.e. the public

telephone network) through cable 475', which provides two lines of service. Such a configuration represents a typical office telephone system.

Transceiver/switch 400 (FIG. 2) is also located inside wiring closet 501, interposing along the portions of extended pairs 405 that is within a few (e.g., 20) feet of PBX 500. The relatively short portions of extended pairs 405 connecting between transceiver/switch 400 and PBX 500 are called twisted pairs 476a–476e (collectively, 476). High capacity communication line 402 also connects to transceiver/switch 400.

Internal to each of offices 512 are several types of communication devices. (The communication devices connected to offices 512d and 512e are not shown because the system shown in FIG. 1b provides only telephone communication with those offices.) Two of these, telephone devices 514a–514c (collectively, telephone devices 514) and video transceivers 509a–509c (collectively, video transceivers 509), connect directly to the corresponding one of extended pairs 405. The wiring that connects these devices to the extended pairs 405a–405c is shown as local networks 511a–511c, respectively. Thus, in FIG. 1b, the telephone wiring that comprises each local network 511 is simply two short telephone cables connecting to the associated extended pair.

Each telephone device 514 connects to the associated local network 511 via a low-pass filter (LPF). As described in the first CIP application, these filters prevent telephone devices 514 from affecting RF energy on the local networks 511. (These filters may be provided as part of splitter 161, which is described in the first CIP application.)

Each video transceiver 509 connects to the corresponding one of extended pairs 405 to transmit and receive video signals. Video transceivers 509 also detect infrared signals, convert them to electrical signals, and feed them onto the extended pairs 405. Individually, each of these processes is described in the parent and first CIP applications. The first CIP application also describes how to combine RF transmitters and receivers into a single device that communicates through a single connection to active telephone wiring.

Video signals received by transceivers 509 are passed to video displays 508a–508c (collectively, video displays 508). Video sources 507a–507c (collectively, video sources 507) also connect to video transceivers 509. Video sources 507 are devices such as video cameras, VCRs, or digital devices, that create electronic signals containing the information necessary to display the type of video pictures addressed in this disclosure. These signals are passed to the connected one of video transceivers 509. The components in offices 512d and 512e are not shown.

Video sources 507a, 507b, and 507c each create a single video signal, called video signals Va, Vb, and Vc, respectively. These signals are fed to video transceivers 509a, 509b, and 509c. Using amplitude modulation, video transceivers 509 convert their input signals, expressing them between the frequencies of 1 Mhz and 6 Mhz, according to the spectral distribution shown in FIG. 3a. (As noted earlier, AM video signals may suffer from crosstalk interference, even at very low frequencies. Thus, the use of AM in this example is arbitrary, and the use of FM may be indicated if the crosstalk loss is small.) These signals are then transmitted onto the network 511 of twisted pair wiring internal to offices 512a, 512b, 512c, respectively.

Because local network interfaces 404 are not provided, the signals applied by video transceivers 509 to local networks 511 transmit directly onto extended pairs 405a–405c. If the wiring internal to the office is a single wire, this wiring can be simply considered an extension of extended pairs 405a–405c.

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The signals applied to extended pairs 405 transmit to signal separators 413 in transceiver/switch 400 (FIG. 2). Signal Va is routed by signal separator 413a to both filter 427a in control signal processor 420 (FIG. 7), and amplifier 408a in subsystem 407a of processor 418 (FIG. 6a). Signal Va is blocked by filter 427a, but is transmitted by amplifier 408a through switch 429 to demodulator 416a. That component demodulates signal Va, passing it along path 488a to signal distribution subsystem 403b. In a similar manner, signals Vb and Vc are applied at baseband to paths 488b and 488c.

Control signals are also transmitted from offices 512. These control signals are infrared (IR) signals issued by infrared transmitters not shown in the figures. Using techniques described in the parent and first CIP application, the IR signals are detected by video transceivers 509, converted to electrical signals, and transmitted onto local networks 511. These signals are applied to extended pairs 405 and transmit to signal separators 413 following the same routes, described above, followed by the video signals. Control signals from video transceiver 509c, for example, are routed by signal separator 413c to both filter 427c in control signal processor 420, and amplifier 408c in subsystem 403b. These signals are demodulated by demodulator 443c, digitized by digitizer 436, and transmitted to master controller 415.

As described above, video signals Va, Vb, and Vc, transmit along paths 488 to switch 462b in subsystem 403b. That component switches these signals, connecting Va to modulator 410a, Vb to modulator 410b, and Vc to modulator 410c. Using frequency modulation, modulators 410a–410c express their inputs signals between the frequencies of 7–22 Mhz. These signals are all applied to switch 401.

Switch 401 switches signal Vb (output by modulator 410b) onto paths 478a and 478c, and signal Vc onto path 478b. Thus, these signals transmit through signal separators 413 and across extended pairs 405 arriving at offices 512. Because of the connections made by switch 401, signal Vb (originating in office 511b) transmits to offices 512a and 512c, and signal Vc (which was sent from office 511c) transmits to office 512b. Internal to offices 512, video transceivers 509 receive these signals and provide them to video displays 508.

It is thus apparent that the system just described allows workers in offices 512a and 512c to hold a video conference with a worker in office 512b. Initially, the workers in office 512a and 512c watch the worker in 512b, while the worker in office 512b watches the worker in office 512c. By sending a control signal to master controller 415, as described above, the worker in office 512b can switch to display the signal from office 512a. This is done as follows. In response to a signal from office 512b, master controller 415 sends a signal to switch 401, instructing it to connect the output of modulator 410a to path 478b instead of connecting the output of modulator 410c to path 478b. Because modulator 410a provides signal Va on output, this effects the desired switching.

Now assume communication line 402 is a coaxial cable that carries three 6 Mhz video signals between the frequencies of 200–218 Mhz. A worker in office 512b can also select a video signal from communication line 402 from transmission to his or her office. This is done in the following manner.

Signals between 200–218 Mhz on communication line 402 transmit to interface 409a where they pass through circulator 421 to block converter 423. That component downshifts these signals to the frequencies between 54 and 72 Mhz, and passes them through splitter 424' in subsystem

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403b to demodulators 426. Next, a control signal is sent from video transceiver 509b to master controller 415, as described above. In response to this signal, master controller 415 directs demodulator 426a to demodulate the signal between 60 Mhz and 66 Mhz, providing it at baseband to switch 462b. In response to another signal from master controller 415, switch 462b connects this signal to modulator 410d. Finally, master controller 415 commands switch 401 to connect the output of modulator 410d (rather than the output of modulator 410a) to path 478b. Because signals passed to path 478b transmit, as described above, to office 512b, the desired signal switching is achieved.

H. A Third Embodiment of Signal Distribution Subsystem 403 (FIG. 5c)

Signal distribution subsystem 403c, which represents a third embodiment of signal distribution subsystem 403, is shown in FIG. 5c. In this embodiment, the demodulation and modulation processes are combined, and only one switch is provided. This has several advantages, which are described below.

Signals transmitted from interface 409 are divided by splitter 426 along five paths. Four paths lead respectively to RF processors 485a–485d (collectively, RF processors 485). The fifth path, labelled path 420b, leads to signal processor 420. The processing of these signals by RF processors 485 is described in the following paragraphs. The processing by control signal processor 420 is described in an earlier section of this disclosure.

Each RF processor 485 selects a channel from among the multiple channels that comprise its input signal and converts the selected channel to the waveform, frequency, and amplitude at which it will transmit through a signal separator 413 and across an extended pair 405. As shown in FIG. 5c, in the first part of this process a selected frequency band is shifted to an intermediate band (using a frequency shifter and local oscillator) and the result is filtered and then demodulated. This creates a basebanded version of the selected signal. (Demodulation of an AM signal involved a process called "detection," while demodulation of an FM signal requires a process called "decoding.")

Selection of channels in RF processors 485 is achieved by tuning the frequency of the local oscillator (l.o.) This is done in response to signals from master controller 415, which are sent over link 446a.

After demodulation, a pre-emphasis process is optionally performed on the basebanded signal to compensate for spectral tilt. As described above and in the first CIP application, this process amplifies the higher frequencies to compensate for the greater attenuation of those frequencies during transmission. After pre-emphasis, the signal is modulated to its final waveform and frequency. (If AM waveforms are used, the modulation process involves mixing the signal with the frequency of a local oscillator. If FM waveforms are used, the modulation process involves "encoding" voltage variations of the signal as frequency deviations of a carrier provided by the local oscillator.) After modulation, the signal is amplified and applied to switch 487.

As described above, each RF processor 485 selects one signal from its input channels and provides that signal at an RF channel. Thus, RF processors 485 are similar to ordinary "cable converters" that receive a band of multiple video signals, select one channel, and output the signal within an different RF channel.

The signals exiting RF processors 485 are labelled "selected signals" in FIG. 5c. Each one will be transmitted to a single signal separator 413, and thus will be transmitted over exactly one extended pair 405. The assignment of the

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outputs of RF processors 485 to signal separators 413 is accomplished by switch 487 under the control (via link 446c) of master controller 415.

Switch 487 receives the selected signals from RF processors 485, and switches them over paths 478a–478c to signal separators 413a–413c. The design and operation of switch 487 is similar to that of switch 462a. As such, switch 487 responds to control signals sent from master controller 415. These signals are transmitted over link 446c. Master controller 415 may connect the output of several of RF processors 485 to the same one of paths 478. Master controller 415 must ensure, in that case, that these outputs do not overlap in frequency.

Subsystem 403c is efficient for systems in which it is unusual to have duplication within the group of signals selected to be sent to local networks 411. Provision of cable TV signals to a small apartment unit is a good example of such a situation. Assume, for example, that communication line 402 carries 60 cable TV signals to a 20 unit apartment house, and that an embodiment of the communication system disclosed herein was installed to provide a single signal to each of those units. This requirement could be satisfied if the embodiment included subsystem 403c and 20 RF processors 485. It should be clear, furthermore, that any embodiment with fewer than 20 demodulators (which are used for channel selection) and 20 modulators would not suffice. (Specifically, they would fail whenever the 20 units each requested a different one of the 60 signals.) If one unit required provision of more than one signal at a time, the requirement could be satisfied by adding an extra RF processor 485. For example, assume that 20 RF processors 485 are provided, and their outputs are switched so that they transmit to different ones of the 20 units. Assume further that they each produce a single video signal between the frequencies of 1–6 Mhz. If one apartment unit required transmission of an additional signal, this could be satisfied by providing an extra one of RF processors 485, whose output was confined between the frequencies of 6–12 Mhz, and that this output would be combined with the other signal transmitting to the unit in question.

I. Alternative Signal Collection Subsystem 407b (FIG. 6b)

Signal collection subsystem 407b, which represents an alternative embodiment of signal distribution subsystem 407, is shown in FIG. 6b. This embodiment is simpler and less expensive than subsystem 407a, yet it allows each local network 411 to transmit a single signal over extended pairs 405 and to have that signal received by transceiver/switch 400 and applied to communication line 402.

Referring to FIG. 6b, signals from signal separators 413 transmit over paths 479 to RF converters 486a–486c (collectively, RF converters 486) within subsystem 407b. Because they prepare the individual signals collected from extended pairs 405 to be combined onto a single conductive path, RF converters 486 are very similar in function to modulators 428 of subsystem 407a. Each RF converter 486 is fixed to shift the energy of its input signal within a particular frequency band to a different band. As shown in FIG. 6b, this process includes mixing the input signal with a local oscillator, and filtering of the resulting output (e.g., to remove all but one sideband). This process creates a new signal, with identical information content, within the new frequency band.

The local oscillators used by each of RF converters 486 are such that the resulting output frequency bands of the three converters 486a–486c do not overlap. This allows the outputs to be combined onto a single conductive path. In a preferred embodiment, the frequency bands confining the

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outputs of RF converters 486 are adjacent in addition to non-overlapping. This minimizes the width of the band occupied by the combined signals.

The signals produced by RF converters 486 are all transmitted to coupler 428'. That component combines the individual signals onto a single conductive path, and passes it to interface 409, which applies the combined signal onto communication line 402, as described above.

1) EXAMPLE #2

Following is an example of communication between transceiver/switch 400 and local networks 411 using an embodiment of the communication system that includes signal distribution subsystem 403c, signal collection subsystem 407b, and interface 409a.

Communication line 402 provides NTSC cable signals at frequencies between 54 Mhz and 850 Mhz. One of the tasks of the communication system in this example is to make the signals between the frequencies of 300 Mhz and 480 Mhz available to local networks 411. Another task is to receive signals from local networks 411 and to add them to this cable between the frequencies of 850 Mhz and 900 Mhz.

The signal from communication line 402 transmits to circulator 421 (FIG. 4a) which feeds it to block converter 423 in interface 409. That device downshifts the band between 300 to 480 Mhz to the band between 54 to 234 Mhz (using an L.O. frequency of 246 Mhz). The result is fed to splitter 426' in subsystem 403c (FIG. 5c). That component splits the energy of the signal five ways, transmitting the signal to RF processors 485 and also along path 420b to control signal processor 420.

Using the system, described above, for communication with master control 415, users at local network 411a select a first channel between 60 and 66 Mhz, and a second channel between 176 and 182 Mhz. In response, master controller 415 instructs converter 485a, via link 446a, to convert the first channel to an AM signal confined between 1–6 Mhz, and it also instructs converter 485b to convert the second channel to an AM signal between 6–12 Mhz. These signals are passed to switch 487. Similarly, users at local network 411b select a third channel between 66 Mhz and 72 Mhz (VHF channel 3) which is converted by RF processor 485c and is provided as an AM signal between the frequencies of 1–6 Mhz. Finally, users at local network 411c select a fourth channel between 182–188 Mhz which is converted by RF processor 485d to the frequencies between 1–6 Mhz. (A standard 6 Mhz NTSC channel can fit between the frequencies 1–6 Mhz by filtering out the part of the vestigial sideband between 0–1 Mhz. This is described more fully in the second CIP application.) Each of the signals output by RF processors 485 transmits to switch 487. In response to signals sent by master controller 415 on link 446c, switch 487 combines the outputs of RF processors 485a and 485b and connects them to path 478a, thus transmitting these outputs to signal separator 413a. Similarly, the output of RF processor 485c is transmitted over path 478b to signal separator 413b, and the output of RF processor 485d is transmitted over path 478c to signal separator 413c. Using techniques described below, signal separators 413 route these signals to the corresponding ones of extended pairs 405. The four video signals thus transmit local networks 411.

Because the highest frequency transmitted from transceiver/switch 400 to local networks 411 is 12 Mhz, in this case, the signals will suffer a relatively small amount of attenuation as they transmit across extended pairs 405. Thus, there is a relatively high probability that these signals will

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arrive at local networks 411 with energy levels sufficient to be efficiently and clearly transmitted to video receivers 419. It is assumed that such is the case in this example. Thus, video receiver 419a receives one video signal amplitude modulated between 1–6 Mhz, and another amplitude modulated between 6–12 Mhz. It imparts an upwards frequency shift of 60 Mhz to these signals, converting them to the frequencies between 60–72 Mhz, i.e., VHF channels 3 and 4. This signal is provided to TV 492a. Similarly, video receivers 419b and 419c shift their inputs so that each provides a single signal at VHF channel 3 to both TV 492b and TV 492c, respectively.

Meanwhile, transmission of signals from local networks 411 to transceiver/switch 400 is also provided. Specifically, video transmitter 417b receives a signal from video camera 494b, converts it to a single 30 Mhz FM video signal between the frequencies of 12–42 Mhz, and transmits it onto local network 411b and across extended pair 405b to transceiver/switch 400. Although it suffers significantly greater attenuation than the lower frequency video signals transmitting in the opposite direction, its wide bandwidth compensates by allowing the receiver to tolerate a lower SNR. This signal transmits to signal separator 413b. That component directs the signal to RF converter 486b (FIG. 6b). Video transmitter 417c feeds a second video signal across extended pair 405c to converter 486c using a similar process.

Within subsystem 407b, RF converter 486b converts its input signal to a 6 Mhz AM signal between 24–30 Mhz, and converter 486c converts its input to a 6 Mhz AM signal between 30–36 Mhz. These signals are passed to coupler 428′ which combines them onto one conductive path and transmits them to block converter 447 in interface 409 (FIG. 4a). Block converter 447 then shifts these signals upwards to the frequency band spanning 850–862 Mhz. Block converter 447 then amplifies the shifted signal, and passes it through circulator 421b and onto communication line 402. Once on that medium, these two signals transmit in the opposite direction of the 30 NTSC signals that transmit between 300–480 Mhz.

J. Transmission and Recovery of Signals from a Single Twisted Pair in a Bundle (FIGS. 9a–9b)

A primary purpose of signal separators 413 is to receive signals from processor 418 and apply them to extended pairs 405 while simultaneously receiving signals from extended pairs 405 and transmitting them to processor 418 and to control signal processor 420. To perform this function, each signal separator 413 is connected between an extended pair 405 and the corresponding one of twisted pairs 476.

The remaining part of the description of signal separators 413 will be cast in terms of signal separator 413b and local network 411b. Two embodiments of signal separators 413 will be described. One embodiment, shown in FIG. 9a and described first, is appropriate when telephone signals transmit over extended pairs 405 in the ordinary manner, i.e., at voiceband frequencies. The other embodiment is appropriate when telephone signals transmit over extended pairs 405 at frequencies above voiceband, as depicted in FIG. 3b. This embodiment is shown in FIG. 9b.

Referring to FIG. 9a, signals that are applied to signal separator 413b are converted and routed in the following manner:

  1) Telephone signals from local exchange 475 transmit across extended pair 476b and through filter 474b, entering the "exchange" port of separator 413b. These signals are applied directly to the "local" port and exit the "local" port unchanged.

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  2) Telephone signals from local network 411b transmit across extended pair 405b, presenting at the "local" port. These signals exit the "network" port, also unchanged.

  3) Signals recovered from communication line 402 that are processed by processor 418 and output by switch 401 (FIG. 5a) transmit across path 478b to the "distribution" port of signal separator 413b. These signals exit the "local" port.

  4) Infrared control signals detected by video receiver 419b and fed onto local network 411b and transmitted (after reception, processing and retransmission by local network interface 404b, if 404b is provided) across extended pair 405b are applied to the "local" port. These signals are targeted for master controller 415, and are routed through the "control" port and along path 477b to filter 427b in control signal processor 420 (FIG. 7). These signals also transmit through the "collection" port and along path 479b, but are ignored by signal selection subsystem 403.

  5) Video signals fed by video transmitter 417b onto local network 411b transmit (after reception, processing and retransmission by local network interface 404b, if 404b is provided) across extended pair 405b to the "local" port. These signals are routed through the "collection" port and transmit across path 479b to amplifier 408b. (Similarly, digital signals fed by transceiver 491c onto local network 411c transmit across extended pair 405c and are routed to amplifier 408c.) These signals also transmit through the "control" port and along path 477b to filter 427b in control signal processor 420. Those signals are blocked from further transmission, however, by filter 427b.

In the embodiment shown in FIG. 9a, signals transmitting through separator 413b are not processed, i.e., they are not amplified, or converted in frequency or waveform.

The major components of signal separator 413b are high pass filter 451, coupling network 459, splitter 458, and inverter 496. These components provide the signal routing and processing described above. It will be appreciated that other embodiments of signal separator 413b that achieve the signal routing and signal conversion described above are also possible.

Transmission of telephone signals through signal separator 413b is straightforward. A simple conductive path connects between the "local" port and the "exchange" port, thereby connecting low pass filter 474b on twisted pair 476b with extended pair 405b. Because low pass filter 474b passes all voiceband energy, this connection completes an simple unbroken conductive path between local exchange 475 and local network interface 404b. High pass filter 451 prevents any telephone signals from diverting towards coupling network 459.

Low pass filters 474 block transmission of the high frequency signals transmitting through signal separators 413 between processor 418 and local network interfaces 411. In addition to preventing the "splitting loss" of these high frequency signals, filters 474 prevent them from creating violations of governmental regulations by conducting onto the public telephone network. Part 68 of the FCC regulations in the U.S., for example, severely limits the energy that can be conducted onto the public network by signals above voiceband and below 6 Mhz.

Video and other non-telephone signals transmitting over extended pair 405b from local network 411b transmit through the "local" port. These signals pass through high pass filter 451 to coupling network 459. They are blocked

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from transmitting towards local exchange 475 by low pass filter 474b (FIG. 2).

At coupling network 459, directional coupling directs signals received from extended pair 405b to splitter 458, isolating these signals from transmitting through inverter 496 (which is described below) to path 478b leading to subsystem 403. Reverse isolation in inverter 496 can also block these signals from path 478b. If this isolation is not provided, these signals may transmit through switch 401 to the output of modulators 410, where they will be blocked by the reverse isolation of those components. (If subsystem 403 follows the embodiment shown in FIG. 5c, reverse isolation will be provided by RF processors 485.)

The energy of the non-telephone signals is divided by splitter 458, so the signals transmit across path 477b to control signal processor 420 and across path 479b to signal collection subsystem 407. An amplifier, (not shown) can be provided internal to splitter 458 to compensate for the 3dB of energy lost during splitting.

Control signals targeted for master controller 415 that transmit across path 477b continue through filter 427b (FIG. 7) in control signal processor 420 to demodulator 443b. (All signals at the frequencies covered by the passband of filter 427b are considered to be intended for communication with master controller 415.) Processing of these signals internal to processor 420 is described below. Other signals, such as video signals, transmitting along path 477b will be blocked by filter 427b.

Signals transmitting across paths 479b to subsystem 407a (FIG. 6a) transmit to amplifier 408b. These signals are amplified and transmitted through switch 429 to one or more demodulators 416. Video signals and signals other than the control signals intended for communication with master controller 415 are then subject to selection by demodulators 416, as described above. Signals not selected terminate at that point. If subsystem 407b is provided in place of subsystem 407a, the same type of signal selection takes place at RF converter 486b.

Signals received by processor 418 from communication line 402 that are processed by processor 418 and output by switch 401 (FIG. 5a) transmit across path 478b to the "distribution" port of signal separator 413b. These signals transmit through inverter 496 to coupling network 459. Directional coupling internal to coupling network 459 directs these signals to high pass filter 451, while isolating them from transmitting to splitter 458. The signals from processor 418 emerge from filter 451 and transmit onto extended pair 405b.

Inverter 496 is supplied to reduce the possibility, described above, of increased crosstalk interference when the same video signal transmits within the same frequency band to multiple local networks 411. This possibility is reduced as follows. Inverter 496, which is an ordinary and inexpensive electronic component, implements a 180 degree phase shift across all frequencies. This phase shift is accomplished by simply converting negative voltages to positive, and vice versa. Thus, the polarity of the output of inverter 496 is the opposite of that of its input, and by placing an inverter 496 as shown in FIG. 9a in approximately half of signal separators 413, the likelihood that the electric fields created by each of the pairs in the group of extended pairs 405 will cancel each other is increased. A component that implements a slight delay in transmission can produce a similar affect if the delay times are slightly different for each of signal separators 413. Both methods tend to prevent the interference from adding coherently.

In addition to providing directional multiplexing, coupling network 459 also balances the signals transmitting

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towards filter 451, and matches the impedance of the conductive path internal to signal separator 413 with the impedance of extended pair 405b. This tends to reduce the radiation of these signals and improve the efficiency of the transfer of energy between pairs 405 and signal separators 413.

Balancing and impedance matching circuitry are shown in FIGS. 6 and 7 of the parent application, for a coupling network that served as a junction of three paths. Those skilled in the art can convert the wound-torroid described therein to achieve the balancing and impedance matching results for this case.

If directional multiplexing in coupling network 459 is not sufficient to prevent transmission of signals from subsystem 403 from transmitting to splitter 458, filtering internal to splitter 458 can prevent these signals from exiting the splitter onto paths 477b or 479b. This type of filtering is possible because, as described above, the frequencies used by signals transmitting towards local networks 411 are different from the frequencies used by signals transmitting towards transceiver/switch 400.

1) EXAMPLE #3

Referring also to FIG. 8, the routing of each of the signals used in the previous example is now described. Signals communicating with local network 411a are routed by signal separator 413a, those communicating with local network 411b are routed by signal separator 413b, and those communicating with local network 411c are routed by signal separator 413c.

Video signal U and video signal V exit switch 401 on conductive path 478a. Video signal U is confined within the 1–6 Mhz band, as shown in FIG. 3a, and video signal V is confined between 7–22 Mhz. These signals transmit along path 478a to signal separator 413a, transmitting through inverter 496 to coupling network 459. They continue on through high pass filter 451 and onto extended pair 405a.

Simultaneously, video signal V exits switch 401 along path 478b at frequencies between 1–6 Mhz. Signal V transmits to signal separator 413b, transmitting through inverter 496 to coupling network 459. It continues on through high pass filter 451 and onto extended pair 405b. Video signal V follows a similar path at similar frequencies, exiting switch 401 along path 478c to signal separator 413c, and transmitting onto extended pair 405c.

Meanwhile, digital signal Y exits switch 401 confined between the frequencies of 6–18 Mhz. It follows a path to extended pair 405c using the same route as video signal V.

Video signals W and X, digital signal Z, and control signals A, B, and C all transmit in the reverse direction. Video signal W and control signal B are both transmitted onto local network 411b. These signals are intercepted by local interface processor 404b and retransmitted across extended pair 405b to signal separator 413b. Inside that signal separator 413b, video signal W and control signal B pass through high pass filter 451 to coupling network 459. These signals are directed by that network towards splitter 458. That component splits the signal energy, transmitting half along path 477b to filter 427b in processor 420 and half along 479b to splitter 408b in processor 418. Filter 427b allows only control signal B to pass through to be processed by control signal processor 420. (Ultimately, control signal B will communicate with master controller 415.) Video signal W and control signal B both pass along path 479b to amplifier 408b in collection subsystem 407a, and exit to switch 429. Only video signal W, however, is transmitted by switch 429 to demodulators 416.

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Video signal X, control signal C, and digital signal Z, meanwhile, are applied to local network 411c and transmit across extended pair 405c to signal separator 413c. The filtering and directional multiplexing internal to that component directs them through splitter 458 and across path 479c to amplifier 408c. The signals input to splitter 408c also transmit across path 477c to filter 427c in signal processor 420.

Finally, control signal A transmits across extended pair 405a to signal separator 413a which directs it to filter 427a in control processor 420 and to amplifier 408a in subsystem 407a.

2) Transmitting Telephone Signals Above Voiceband (FIG. 9b)

The embodiment of signal separator 413b shown in FIG. 9b is now described. This embodiment is used when signals received from communication line 402 are transmitted by transceiver/switch 400 across extended pair 405b using, in addition to higher frequencies, frequencies at voiceband. (The spectral distribution of these signals is shown in FIG. 3b.) As described above, signal separator 413b and local network interface 404b cooperate, in this embodiment, to transmit telephone signals at frequencies above voiceband.

Referring to FIG. 9b, the major components of signal separator 413b are coupling network 422, telephone signal processor 424, and impedance matcher 480. Processor 424 works in conjunction with local interface 404b to communicate telephone signals across extended pair 405b at RF frequencies.

Telephone signals from local exchange 475 transmit at voiceband through low pass filter 474b (FIG. 2) and through the "exchange" port of separator 413b to conversion circuitry 464, which is part of processor 424. Circuitry 464 converts all of these signals to RF frequencies. The converted signals include voice, ringing, and hookswitch signals. The converted telephone signals are transmitted through bandpass filter 425 to coupling network 422.

Filter 425 passes energy within the bands occupied by the telephone signals in their RF form, but blocks all other signals, including voiceband signals. This prevents conversion circuitry 464 from loading down non-telephone signals that transmit to processor 424.

The telephone signals transmitted from local exchange 475 always exit the "local" port of signal separator 413b because filters located on the paths exiting network 422 block these signals from exiting through the "collection," "distribution," and "control" ports. (This filtering is described below.) These signals transmit onto extended pair 405b. They are received and converted back to their original form by local network interface 404b as will be described below. The recovered signals are then transmitted onto local network 411b as normal voiceband signals.

Telephone signals transmitting in the reverse direction, from telephone device 414b to local exchange 475, are converted in the following manner. Local network interface 404b intercepts the signals from telephone device 414b, which are at voiceband, converts them to RF signals, and transmits them across extended pair 405b. Processing of telephone signals by local network interfaces 404 is described in greater detail below.

Telephone signals in the RF band from extended pair 405b transmit through the "local" port of signal separator 413b to coupling network 422. These signals then transmit to telephone signal processor 424 but are blocked from exiting network 422 towards the "collection," "distribution," and "control" ports by filters connected to the paths leading to

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those ports. (Coupling network 422 is described in greater detail below.) These telephone signals pass through filter 425 to conversion circuitry 464 which converts them back to voiceband, and transmits them to filter 474b and across twisted pair 476b to local exchange 475.

Means to convert telephone signals from voiceband to RF signals and back to voiceband are well known and can be used to implement the functions of conversion circuitry 464 and the companion conversion component in local network interfaces 404. Indeed, common cellular or cordless telephones convert voiceband, switchhook, and ringing signals to RF frequencies to transmit the signals over a wireless link to a telephonic communication line.

Routing of non-telephone signals through signal separator 413b (as shown in FIG. 9b) is now described. Coupling network 422 includes directional couplers 466 and 467 and splitter 468. Couplers 467 and 466 each have a joined port and left and right isolated ports. Signals presenting at a joined port pass to through to each of the isolated ports. (The signal energy is evenly split.) Signals presenting at an isolated port exit through the joined port, but are blocked, (e.g. have a 30 dB loss) from exiting the other isolated port.

Signals from extended pair 405b pass through the "local" port and present at impedance matcher 480. These signals include both telephone signals, control signals, and signals destined for transmission to communication line 402. Impedance matcher 480 matches the impedance of the telephone line to the circuitry internal to transceiver/switch 400.

After passing through impedance matcher 480 these signals transmit to directional coupler 467, exiting through both of the isolated ports and transmitting to the joined port of coupler 466 and splitter 468. Signals presenting at the joined port of coupler 466 exit both of the isolated ports. As can be seen by tracing the paths, signals exiting the isolated port leading towards switch 401 in subsystem 403 (i.e., the right isolated port of coupler 466) pass through to modulator 410b where they are blocked (i.e. meet a high impedance) by the reverse isolation at the output of that device. A filter can be provided at the output of modulator 410b to prevent loading down of these signals.

From among the signals that pass out the left isolated port of coupler 466 leading towards processor 424, only telephone signals are received by processor 424. These are processed as described above. Non-telephone signals are blocked by filter 425 in that processor.

Signals from extended pair 405b that present at the joined port of coupler 467 and exit the left isolated port towards splitter 468 are split and routed to filter 427b in control signal processor 420 and amplifier 408b in subsystem 407 of processor 418. As will be described later on, filter 427b blocks signals other than those at frequencies used by the control signals that communicate with master controller 415. Thus, processor 420 separates the special control signals from the group of "collected" signals.

As described above, signals presenting at amplifier 408b are amplified and transmitted through switch 429 to demodulators 416. Video signals and signals other than telephone signals and control signals intended for communication with master controller 415 are then subject to selection by demodulators 416, as described above. Signals not selected terminate at that point. (Thus, control signals and telephone signals will terminate.) If subsystem 407b is provided in place of subsystem 407a, the same type of signal selection takes place at RF converters 486.

As described above, the signals received by processor 418 from communication line 402 that are intended for trans-

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mission to local network 411b are output from switch 401 (in subsystem 403a, FIG. 5c). These signals exit along path 478b, pass through the distribution port of signal separator 413b and through inverter 496 to the right isolated port on directional coupler 466 in coupling network 422. (This path can be traced in FIGS. 2 and 9b.)

Signals passing through the right isolated port of directional coupler 466 exit through the joined port of coupler 466. (They are substantially blocked from exiting the left isolated port by the directional multiplexing of coupler 466; filter 425 blocks the portion of the energy that exits from the left isolated port.) They then pass through the left isolated port of coupler 467, to the joined port of coupler 467. (They are blocked from exiting the other isolated port of coupler 467 by the directional multiplexing and, ultimately, by the reverse isolation of modulators 410.) Finally, they pass though the joined port of coupler 467, through impedance matcher 480b onto extended pair 405b. The impedance matching enables these signals to feed onto extended pair 405b, which has a different impedance, without substantial signal reflections.

K. Signal Processing at the Local Network Interface (FIGS. 10–13)

The signals fed to one of extended pairs 405 by transceiver/switch 400 are received at the opposite end by the corresponding one of local network interfaces 404 which processes these signals and retransmits them onto the corresponding one of local networks 411. If two-way communication between transceiver/switch 400 and local networks 411 is performed, each local network interface 404 also receives signals transmitted onto local networks 411 and transmits them onto the corresponding one of extended pairs 405.

The primary function of local network interfaces 404 is to process the signals intercepted from extended pairs 405 so that when they are retransmitted their ability to communicate to the RF receivers connected to local networks 411 will be enhanced. Processing of signals transmitting towards transceiver/switch 400 provides similar benefits.

A particularly important process performed by local network interfaces 404 is amplification. This allows signals transmitting along the transmission path between transceiver/switch 400 and the RF receivers on local networks 411 to be amplified at an intermediate point, boosting their energy levels up to the maximum limit (i.e., the limit at which they radiate RF energy just below governmental limits.) This re-amplification will improve the SNR at the receive end, increasing the attenuation that the signal can encounter along the transmission path while still being successfully received. Processing that converts signal waveform and frequency can also be useful, as described below.

In some embodiments, particularly those where a video signal is transmitted over one of extended pairs 405 at baseband frequencies (FIG. 3B), telephone signals transmit from transceiver/switch 400 to local network interfaces 404 at RF frequencies, having been converted from voiceband by a telephone signal processor 424 in one of signal separators 413. When telephone signals transmit at RF frequencies, local network interfaces 404 convert the signals received from extended pairs 405 to ordinary voiceband telephone signals, and feed them onto the corresponding local networks 411 for reception by telephone devices 414 in the ordinary manner. Conversion also takes place in the opposite direction. I.e., voiceband telephone signals from devices 414 that transmit across local networks 411 are received by the corresponding local network interfaces 404, frequency converted, and applied to the corresponding one of extended pairs 405 at RF frequencies.

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A general embodiment of a local network interface 404 is shown in FIG. 10. The description that follows will be cast in terms of local network interface 404b, but applies, of course, to any one of local network interfaces 404 shown in FIG. 1a.

Referring to FIG. 10, the principle components of local network interface 404b are the telephone signal processing section 470, general signal processing section 471, coupling networks 437 and 449, and high pass filter 463. All signals from extended pair 405b transmit to coupling network 437, and high-frequency (i.e., non-voiceband) signals from local network 411b transmit through high pass filter 463 to coupling network 449. Directional multiplexing and filtering in coupling networks 437 and 449, and filtering on paths connected to these coupling networks, cause the converging signals to be routed as follows. Telephone signals from extended pair 405b are blocked by filters 438, 445 in general signal processing section 471 and thus are routed through telephone signal processing section 470 and onto local network 411b (and are blocked from coupling network 449 by high pass filter 463). Telephone signals also transmit across the same path in the opposite direction. Non-telephone signals from extended pair 405b are routed to general processing section 471, and non-telephone signals from section 471 pass through coupling network 437 to extended pair 405b. Also, non-telephone signals from local network 411b transmit to general processing section 471, and non-telephone signals from general processing section 471 transmit onto network 411b.

The transmission of telephone signals through local interface 404b and the details of telephone signal processing section 470 are described first. That description also includes a description of two particular embodiments of coupling network 437. Several embodiments of general processing section 471 and coupling network 449 are described after that.

1) Transmission of Telephone Signals across Local Interface 404b (FIGS. 13a, 13b)

When non-telephone signals transmitting on extended pair 405b do not have energy at voiceband frequencies, (e.g. the video signals represented in FIG. 3a or 3c) signal separators 413 according to FIG. 9a are used, and the telephone signals communicating between local exchange 475 and telephone devices 414b are confined to the voiceband. FIG. 13a shows coupling network 437a which is an embodiment of network 437 used when telephone processor 424 is not included in signal separator 413b. In this case, the telephone signals are at voiceband.

Referring to FIG. 13a, voiceband telephone signals from extended pair 405b that transmit to interface 404b are blocked by high pass filter 472 in coupling network 437a, passing instead through low pass filter 442, which is designed to pass only energy at voiceband frequencies, in telephone signal processing section 470a. These signals continue on to local network 411b. (They are blocked from the alternative path by high pass filter 463.) Transmission of telephone signals in the opposite direction traces the reverse path. Thus, an unbroken path for voiceband signals from telephone device 414b (FIG. 1a) to local exchange 475 is provided.

FIG. 13b shows coupling network 437b and telephone signal processing section 470b, which are specific embodiments of network 437 and section 470. Section 470b processes telephone signals that transmit over extended pair 405b at frequencies above voiceband (e.g., at RF).

All signals from extended pair 405b are applied directly to coupler 437b. Coupler 437b matches the impedance of

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each of the five paths that converge at its ports. Coupler 437b also balances the signals transmitting from interface 404b onto extended pair 405b. Finally, coupler 437b allows all converging signals to flow through freely to the other ports, meaning that routing of signals through that coupler is determined by the surrounding filters. (An example of such a coupler is shown in the first CIP application.)

Telephone signals transmitting over extended pair 405b at frequencies above voiceband that transmit to coupler 437b are routed to band pass filter 454 and are blocked on all other exiting paths by filters that pass different frequency bands. The signals passed by filter 454 continue on to telephone signal converter 452. Converter 452 converts these signals to voiceband and transmits them through low pass filter 455 to local network 411b where they communicate with telephone device 414b in the ordinary manner. High pass filter 463 blocks these signals from transmitting along the alternative path.

In the reverse direction, processor 452 receives telephone signals at voiceband from local network 411b via low pass filter 455. Processor 452 converts these signals to RF and passes them through filter 453 to coupler 437b. These signals transmit only onto extended pair 405b because they are blocked from the other paths (by filters 445, 438, and 454). This completes a two-way telephone communication link using RF between processor 452 and telephone signal processor 424 in signal separator 413b at transceiver/switch 400.

2) Transmission of Non-Telephone Signals from Extended Pair 405b to Local Network 411b

Referring again to FIG. 13a, non-telephone signals from extended pair 405b that transmit to coupling network 437a pass through high pass filter 472 to coupler 483. They are blocked from the alternative path by filter 442, which passes only voiceband signals.

Coupler 483 matches the impedance of each of the three paths that converge at its ports. Coupler 483 also balances the signals transmitting from interface 404b onto extended pair 405b.

In one embodiment of coupler 483, all signals converging at its ports flow freely through to the other ports. This means that the routing of signals through couplers 483 is determined by the filters on the connecting paths. In an alternative embodiment of coupler 483, isolation is provided between the two paths leading to local processor 439 (FIG. 10). This increases the separation provided at coupling network 483 by filters 445 and 438.

Referring to FIG. 13b, coupler 437b matches the impedance of each of the paths that converge at its ports and balances the signals transmitting from interface 404b onto extended pair 405b. All signals converging at coupler 437b pass freely out the other ports, meaning that routing of signals through coupler 437b is determined by the filters connected to its ports.

Non-telephone signals received from pair 405b that transmit to coupler 483 (in FIG. 13a) or coupler 437b (in FIG. 13b) exit on the path leading to filter 438 (FIG. 10). Filter 438 passes only energy at frequencies used by non-telephone signals transmitted by transceiver/switch 400, allowing those signals to pass through to local processor 439. The same signals are blocked along the path leading from network 437 by filter 445, which passes only energy at frequencies used by non-telephone signals transmitting towards transceiver/switch 400. (In FIG. 13b, non-telephone signals received from extended pair 405b are also blocked from the two other paths by filters 453 and 454.) Thus, all non-telephone signals received from extended pair 405b are received by local processor 439.

After processing, local processor 439 transmits these signals to filter 460, and they ultimately transmit onto local network 411b, as will be described below. To avoid interference with telephone communication on local network 411b, signals transmitted by processor 439 to filter 460 are always provided at frequencies above the ordinary telephone voiceband.

One important function of processor 439 (and of local network interfaces 404) is to amplify non-telephone signals received from filter 438, relaying them onto local network 411b at a higher energy level, thereby increasing the SNR at the input to the RF receivers connected to local networks 411. Without this increase, the attenuation in transmitting from transceiver/switch 400 may prevent signals from reaching the receive end with sufficient SNR.

Another function of processor 439 is to convert signals from filter 438 to the waveform (i.e., the modulation method) and frequency at which they will transmit onto local network 411b. Changing the waveform and frequency can simplify the design of the RF receivers of these signals, e.g., video receivers 419 and transceiver 491c. This is especially true if video is transmitted over pair 405b in FM form, or if the video signals transmitted by interface 404b onto local network 411b must coordinate with video signals transmitting locally, e.g., from video transmitters 417b to video receiver 419A. (Choosing waveforms for various video signals transmitting across a local network and arranging their frequency bands to simplify receiver design is thoroughly discussed in the second CIP application.) Various embodiments of processor 439, some of which perform frequency and waveform conversion, all of which perform amplification, are given below.

Additional details of the routing of signals transmitting from processor 439 to local network 411b are now described. Filter 460 blocks energy at all frequencies except those used by signals fed to that filter from processor 439. The signals passed by filter 460 transmit to coupling network 449.

Coupling network 449 serves as a junction for signals converging from three paths. Signals flow freely through this junction, exiting each of the opposite two paths. Thus, filters 460, 461, and 463 determine the routing of the signals at coupling network 449.

Signals transmitting to coupling network 449 from filter 460 exit through the port leading to high pass filter 463. That filter blocks only voiceband signals, allowing the signals from processor 439 to pass through onto local network 411b. Filter 455 in telephone signal processor section 470b (FIG. 13b) blocks signals from processor 439 from transmitting along the alternative path. Filter 442 in telephone signal processor section 470a (FIG. 13a) performs a similar function. Because it is a low-pass filter, filter 442 also suppresses the energy of transients and harmonics of voiceband signals originating at telephone device 414b (or other telephone devices connected to local network 411b) from transmitting onto extended pair 405b. Because these may contain significant energy at higher frequencies, they can ordinarily cause interference with the RF signals communicating over that pair. The low pass filters that connect between devices 414 and the local networks 411 can also suppress these harmonics.

In addition to serving as a junction, coupling network 449 matches the impedance of the wiring of local network 411b to the circuitry internal to interface 404b. It also balances RF signals flowing from processor 439 onto local network 411b, and unbalances RF signals flowing in the opposite direction. These functions tend to minimize radiation and increase the

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efficiency of the transfer of RF energy between local net-
work 411b and interface 404b.

Referring also to FIG. 8, the following example shows
how signals from extended pair 405a are coupled by local
network interface 404a onto local network 411a. Video
signals U and V are fed onto extended pair 405a by signal
separator 413a in transceiver/switch 400. Signal U is ampli-
tude modulated in the 1-6 Mhz band, while signal V is
frequency modulated in the 7 to 22 Mhz range. At local
network interface 404a, these signals transmit to network
437, and exit towards filter 438. (They are blocked from the
other paths by the surrounding filters.) Signals U and V pass
through filter 438 and are received by processor 439.

Processor 439 demodulates video signal V, and remodu-
lates it using AM between the frequencies 24-30 Mhz at a
signal level of 40 dB mV. In parallel with this process,
processor 439 demodulates video signal U and remodulates
it using AM between the frequencies 12-18 Mhz and at a
signal level of 40 dB mV. These signals are combined onto
a single conductive path and fed through filter 460 to
coupling network 449. They pass through that network,
exiting through filter 463 and onto local network 411a.
Video receiver 419a recovers these signals from the
network, and block converts them upwards by 164 Mhz,
providing them to television 492a at 176-182 Mhz (VHF
channel 7) and 188-194 Mhz (VHF channel 9). (A design
for a video receiver that performs such a conversion is given
in the second CIP application.) One of the detailed embodi-
ments of processor 439 shown below includes import pro-
cessor 440b. That component is designed to conduct the
processing required to perform the conversion of video
signal U and video signal V used in this example.

3) Transmission of Non-Telephone Signals from Local
Network 411b to Extended Pair 405b

Video transmitter 417b connects to local network 411b to
transmit signals at frequencies above voiceband. Examples
of these signals are ordinary video signals from video
cameras, digital signals from computers, and control signals
from infrared transmitters. These signals are referred to as
non-telephone signals because they are not meant to com-
municate to local exchange 475. Techniques that transmit
these signals across networks such as local network 411b are
described in the parent and first and second CIP applications.

Certain control signals transmitted by video receiver 419b
are intended to communicate with master controller 415 in
transceiver/switch 400. These signals indicate, among other
things, which signals are to be recovered from communica-
tion line 402 and transmitted over extended pair 405b to
local network 411b. Master controller 415 can make these
determinations because it controls certain other components
in transceiver/switch 400, as described above.

Because many potential users are familiar with issuing
control signals using infrared transmitters, that is the pre-
ferred method of originating these control signals, e.g.,
issuing infrared signals from remote control transmitter
493b. Video receivers 419b detect these infrared patterns
and convert them to voltage variations that are applied to
local network 411b and received by local network interface
404b. That component relays the control signals across
extended pair 405b to transceiver/switch 400 where it is
received, as described above, by control signal processor
428.

Referring to FIG. 10, non-telephone signals fed to local
network 411b for transmission to transceiver/switch 400, are
blocked by a high impedance at telephone signal processing
section 470. (In the embodiment of section 470b, this
impedance is supplied by low pass filter 455. In the embodi-

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ment of section 470a, this impedance is supplied by low pass
filter 442.) Because these signals are expressed in RF,
however, they pass through high pass filter 463 to coupling
network 449. These signals will exit that network towards
filter 461, but will be blocked from the other exit by filter
460. (As described above, filter 460 only allows energy used
by signals transmitting from processor 439 to pass.) Thus,
signals from video transmitter 417b will pass through filter
461 to processor 439.

Among the signals received from filter 461, those
intended for transmission to communication line 402 are
converted by processor 439 to the waveform, frequency, and
amplitude at which they will be fed to extended pair 405b.
The relationship between these characteristics and the reli-
ability of communication over extended pair 405b was
described above. Processor 439 feeds the converted signals
through filter 445. The signals are then forced by the filtering
(i.e., blocked by filters 438 and 442) through coupling
network 437 and onto the corresponding extended pair 405b.

In some embodiments, signals recovered by processor
439 from local network 411b are processed and retransmit-
ted onto that network. Such a procedure, and its attendant
advantages, is described in the second CIP application. That
procedure is included as an option of the communication
system described herein because local network interfaces
404 provide a natural place to implement such a retransmis-
sion process. A specific embodiment of processor 439 that
retransmits signals back onto local network 411b is
described below.

Referring also to FIG. 8, the following is an example of
transmission of signals from local network 411b through
processor 439 to extended pair 405b. Video transmitter 417b
receives video signal W at baseband from video camera
494b, amplitude modulates it between 6-12 Mhz, and feeds
it onto local network 411b where it transmits to filter 463 in
local network interface 404b. Being blocked by low pass
filter 455 (or by filter 442 when the embodiment shown in
FIG. 13a applies) and filter 460, signal W transmits through
high pass filter 463, coupling network 449 and filter 461 to
processor 439. Processor 439 converts video signal W to an
FM signal between 24-54 Mhz, and transmits it through
filter 445 and coupling network 437 onto extended pair
405b. (The relatively wide bandwidth is advantageous
because, being at relatively high frequencies, the signal will
suffer more attenuation and be received at a lower SNR.
Increasing the bandwidth compensates for this by making
the reception process more sensitive.)

Meanwhile, video receiver 419b detects control signal B
(FIG. 8) which is issued by the user with infrared remote
control transmitter 493b. Video receiver 419b converts this
signal to voltage variations within the 0.5 Mhz band cen-
tered at 23 Mhz, and feeds the signal onto local network
411b. Following the same route as video signal W, control
signal B transmits to processor 439. Processor 439 receives
control signal B and video signal W combined on the same
conductive path. After processing, control signal B is at a
higher energy level (Signal W is converted as described
above.) The two signals are fed through filter 445 to cou-
pling network 437. Filtering at network 437 routes the
combined signal onto extended pair 405b. One of the
detailed embodiments of processor 439 shown below
includes export processor 441b. That component is designed
to conduct the processing of video signal W and control
signal B used in this example.

It will be appreciated that the part of signal processor 439
that receives RF signals from pair 405b and the part that
feeds signals onto pair 405b, together with coupling network

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437 and filters 438, 445, and 442 comprise a transceiver that performs two-way RF communication with a network of active twisted pair wiring, specifically, extended pair 405b. A complete description of the basic signal processing elements required of such a transceiver is given in the first CIP application. The processing implemented by components 439, 437, 445, 442, and 438 of this disclosure includes those elements.

It will further be appreciated that the part of signal processor 439 that receives RF signals from local network 411b and the part that feeds signals onto local network 411b, together with coupling network 449 and filters 442, 460, 461, and 463 also comprise a transceiver that performs two-way RF communication with a network of active twisted pair wiring, specifically, local network 411b. A complete description of the basic signal processing elements required of such a transceiver is also given in the first CIP application. The processing implemented by components 449, 460, 442, 461, 463, and 439 of this disclosure includes those elements.

4) Details of Specific Embodiments of Local Processor 439 (FIGS. 11a, 11b)

FIG. 11a shows processor 439a which is a specific embodiment of processor 439. In processor 439a, all of the non-telephone signals received from local network 411b are transmitted through filter 445 and onto extended pair 405b, and all non-telephone signals received by that processor from extended pair 405b are transmitted through filter 460 and onto local network 411. This simplifies the design, enabling processor 439a to be separated into two independent processors. As is seen in FIG. 11a, non-telephone signals transmitting from extended pair 405b onto local network 411b transmit through import processor 440. Non-telephone signals transmitting in the other direction, from local network 411b to extended pair 405b, transmit through export processor 441.

Import processor 440 converts the signals it receives from extended pair 405b to the waveform, frequency, and signal level at which they are fed through filter 460, network 449, and high pass filter 463 onto local network 411b. FIG. 11b shows three different embodiments of import processor 440.

Processor 440a, which is shown at the top of FIG. 11b, does not alter the waveform or frequency of its input. Rather, processor 440a simply adjusts the signal energy to a selected level. Typically, this adjustment results in an amplitude increase, thereby increasing the SNR at the RF receivers connected to local network 411b.

Typical governmental regulations do not limit the total energy that can be radiated by a single device. Rather, each individual signal transmitted by an RF device faces limitations on the radiation it can generate. For this reason, transceiver/switch 400 feeds each signal to extended pairs 405 at energy levels that create radiation just below the legal limits. This will maximize the SNR at the opposite end of extended pairs 405. For the same reason, import processor 440a boosts the levels of the signals it receives back to these "maximums" before retransmission onto local network 411b.

Because signals at higher frequencies encounter more attenuation, they will be received at levels further below the maximum than lower frequency signals. Thus, import processor 440a provides a gain that increases with frequency. This is achieved by a two phase process. In the first phase, the same gain is imparted to signals at all frequencies by amplifier 499. In the second phase, filter 497 applies an attenuation to the signal that decreases with increasing frequency, thus providing an output signal whose gain

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increases with frequency. Although this two-phase process is described herein, other techniques that impart a "sloped gain" can be used.

To provide a device that can be used in a variety of installations, processor 440a allows the overall gain and the slope of the gain to be adjusted. As shown in FIG. 11b, these adjustments are preferably manual. (Alternatively, the adjustments can be made automatically using suitable feedback techniques.) Manual means are acceptable because the levels of signals received from transceiver/switch 400 are not likely to change, making an initial adjustment sufficient. Also, it is likely that local network interfaces 404 will be professionally installed, removing another reason for providing automatic adjustment.

Processor 440b (shown in the center of FIG. 11b) is designed to receive multiple (two in the embodiment shown) signals from extended pair 405c. (Because they are recovered from a single pair, of course, each signal will be confined within different frequency bands.) Processor 440b demodulates, basebands and then remodulates each signal, providing them at a specific waveform, frequency, and energy level.

Processor 440b is especially useful when the signals transmitted over pairs 405 are FM video signals. If video signals transmit onto local networks 411 in FM form, video receivers 419 must convert them to AM because most ordinary televisions only receive AM signals. (Some receive unmodulated signals, some receive FM video signals.) Referring to FIG. 8, processor 440b can implement the conversion that local network interface 404a performs on video signals U and V before those signals are transmitted onto local network 411a.

The functioning of processor 440b is as follows. The combined signals are divided in power by splitter 430, transmitting to demodulators 431a and 431b. Each of those components basebands a different one of the signals. The basebanded signals transmit to modulator/amps 432a and 432b, respectively. These components convert their basebanded signal to the new waveform, frequency band, and energy level, and feed them to coupler 433. (FIG. 11b shows the individual steps of the modulation and demodulation processes inside the blocks representing demodulator 431a and modulator 432a.) Coupler 433 recombines the signals, which are expressed within non-overlapping frequency bands, providing them to filter 460 along the same conductive path.

Import processor 440c (shown at the bottom of FIG. 11b), is designed to block convert signals from one frequency range to a second frequency range. Referring to FIG. 8, assume that in addition to video signal v transmitting between 1 and 6 Mhz, a second video signal (not shown in FIG. 8) is amplitude modulated between 6–12 Mhz and transmits across extended pair 405b. Both these signals transmit to import processor 440c and are upshifted in block converter 434 by 60 Mhz, thereby converting them to frequency bands of 61 MHz–66 MHz (VHF channel 3) and 66 MHz–72 MHz (VHF channel 4), respectively. Because these channels are tunable by ordinary televisions, video receiver 419b will not need to convert the signals before transmitting them to television 492b. The signals are amplified after conversion, then exit towards filter 460 and are applied to local network 411b. This block conversion can also enable the video signals to coordinate (i.e., avoid interference) with video signals transmitting locally across local network 411b, i.e., between video transmitter 417b and video receiver 419b.

Import processor 440c includes sloped amplifier 498 and block converter 434. Sloped amplifier 498 performs a pro-

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cess similar to that of import processor 440a. It amplifies the input, but imparts more gain to the higher frequencies because they have attenuated more during transmission across the associated one of extended pairs 405. The output of sloped amplifier 498 is fed to block converter 434. As is seen in FIG. 11b, that component shifts the signal in frequency by an amount equal to the frequency of a local oscillator. In the example above, the shift is 60 Mhz. The resulting signal is passed through a filter, amplified, and transmitted to filter 460. (In the example above, filter 460 would pass only the frequencies between 60–72 Mhz.) To allow import processor 440c to be used in a variety of installations, the gain of the amplifier in block converter 434 is manually adjustable, as is the slope of amplifier 498. (In practice, these settings would be adjusted to provide all of the output signals at levels that generate radiation slightly below the governmental limit.)

Export processor 441 receives signals from local network 411b and converts them to the waveform, frequency, and signal level at which they are fed, ultimately, to extended pair 405b. Two embodiments of export processor 441 are shown in FIG. 11c, and are now described.

Export processor 441a amplifies the level of the signal applied to it, providing these signals on output at levels that will create radiation on the extended pair 405 just below the legal limits. As such, it must impart a higher gain to the higher frequency signals because they have suffered more attenuation in transmitting across network 411b. Thus, it works in a manner identical to import processor 440a (FIG. 11b), and its components, amplifier 499 and sloped filter 497, correspond in function to amplifier 499 and sloped filter 497 of processor 440a.

Export processor 441b is designed to provide frequency and/or waveform conversion for one of its input signals, and to simply adjust the energy level of the others. The signals received by export processor 441b pass to splitter 484, which directs the signals to both demodulator 457 and filter 482. Demodulator 457 selects one of the signals for demodulation. The basebanded result is passed to modulator 456 which remodulates the signal, providing it with a different waveform, frequency, and energy level. (The typical modulation and demodulation steps are shown internal to the blocks representing modulator 457 and demodulator 456.) Filter 482, meanwhile, filters out the signal selected by demodulator 457, passing the remaining signal or signals for amplitude adjustment by gain control 481 to a fixed level, typically resulting in a level increase. (Gain control 481 performs its processing in a manner identical to the processing performed by export processor 441a and import processor 440a.) The output of gain control 481 and the output of modulator 456 (which are in different frequency bands) are then combined onto the same conductive path by coupler 465, and passed to filter 445.

Referring to FIG. 8, an example of the processing conducted by export processor 441b is given. Video receiver 419b provides control signal B between 22.75–23.25 Mhz and feeds it onto local network 411b, and video transmitter 417b feeds video signal W onto local network 411b, using amplitude modulation between 6–12 Mhz. At local network interface 404b, video signal W is selected and demodulated by demodulator 457, and then frequency modulated between 24–54 Mhz by modulator 456. Control signal B, meanwhile, passes through filter 482 to gain control 481, which increases its energy level. These two signals are then joined by coupler 465 and fed onto extended pair 405b by other components of local network interface 404b.

5) An Embodiment of Local Processor 439 that Retransmits Signals Recovered from Local Network 411b (FIG. 12)

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As discussed above, FIG. 10 shows a general embodiment of processor 439. As can be seen from that figure, processor 439 receives signals from local network 411b and also transmits signals onto that network. (The signals transmitted onto local network 411b are either received from extended pair 405b, received from local network 411b, or they are generated internally.) In the more specific embodiments shown in FIGS. 11a–11c, only those signals recovered from extended pair 405b are fed onto local network 411b.

Processor 439b, shown in FIG. 12, is a different specific embodiment of processor 439, and is described in this section. In contrast to processor 439a, the signals transmitted onto local network 411b by processor 439b can come from two sources: 1) they can be signals recovered from extended pair 405b, or 2) they can be signals received from local network 411b.

There are several reasons to provide for both sources. One of the advantages is that it allows for certain simplifications and economies in design of the components that receive the video signals, i.e., video receivers 419. It also allows for modifications of the retransmitted signals to be applied by a single device, i.e., the device performing such retransmission. Such modifications can include superposition of textual information such as a clock, a channel display, etc.

These advantages are described in the second CIP application, wherein a similar signal processing device, RF video processor 312, is described. That device recovers video signals from a network of telephone wiring, processes those signals, and retransmits them onto the same network. Processor 312 is slightly modified in this application to provide processor 439b. More precisely, RF/video processor 312, shown in FIG. 2 of the second CIP application, is modified and combined with master controller 316 of the second CIP application to provide a specific embodiment of the following elements of this application: processor 439, filters 461, 460, 463, and coupling network 449.

To see how RF/video processor 312 is modified, realize that two of the functions of processor 439, receiving signals from network 411b and transmitting them onto that network, are already part of processor 312. The other two functions, receiving signals from extended pair 405b and converting signals and feeding them through filter 445 and onto extended pair 405b, are provided in the following manner.

As described in the second CIP application, signals output from graphical processors 329 are basebanded video signals, but they can also be basebanded signals of a general nature. Any one of these outputs can be split, under control of master controller 316, and fed to processor 473. Processor 473 converts the signal to the waveform, frequency, and amplitude at which it will transmit across extended pair 405b. Finally, the signal is fed through port 321 to filter 445. After passing through that filter, the signal follows the transmission path, described above, onto extended pair 405b.

As described earlier, signals received from extended pair 405b pass through filter 438. To feed these signals to processor 312, a conductive path is provided between filter 438 and port 315. (In the second CIP application, one intended function for port 315 was to input cable TV signals.) Thus, this simple connection, plus processor 473, are the only additions necessary to adapt processor 312 to perform all of the functions of processor 439.

Note that in the embodiment shown in FIG. 12, filter 461 is actually two separate filters, as is filter 460. Furthermore, each conductive path leading to and from those filters is actually composed of two separate parallel paths. This separation is due to the fact that in this embodiment,

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processor 439 recognizes a separate class of signals and processes them differently.

The signals in the special class are those intended communicate with master controller 316, and also signals sent by controller 316 that are intended to control devices that receive signals from or transmit them to local network 411b. In particular, the control signal from infrared transmitters 493b are detected by video receiver 419b, converted to voltage, and fed onto network 411b. This signal passes through filter 334 to processor 330.

In the reverse direction, master controller 316 instructs control signal creation circuitry 338 to generate control signals and feed them through filter 336 (part of filter 460) onto local network 411b. These signals will be received by video transmitters 417 and converted to infrared signals that are broadcast into the environment where they can be detected by nearby infrared responsive devices, such as TV 492b. This communication process is described more fully in the second CIP application.

L. Boosting Signal Power within a Wiring Closet (FIG. 14)

As discussed above, the twisted pairs providing telephone service to the units of an apartment building often converge in a room in the basement of such a building, providing a point of common access to a large number of units. Other "common points of access" often available in an apartment building are the wiring closets that are often located on every floor. These provide an intermediate point of convergence to the telephone wires of the units on that floor. Bundles of multiple twisted pair wires often lead from the basement location to the wiring closets.

Locating transceiver/switch 400 in the basement is an economical alternative because it frees one from the requirement of bringing communication line 402 to the wiring closet of each floor, and because one device embodying transceiver/switch 400 can suffice for the entire building. (Although this device will need to have more internal components, economies will be enjoyed in hardware, maintenance, and installation.)

In very large apartment buildings, however, the distances may be such that extended pairs 405 will be relatively long for certain apartment units. As is described above, this increases the attenuation of transmission, preventing the use of higher frequencies and limiting the number of signals that can transmit at a single time. One solution to this problem is to provide amplification of the signals at an intermediate points, such as in the wiring closets.

Amplification at an intermediate point is most useful if half of the signal attenuation occurs before amplification, and half occurs afterwards. It can be shown that this maximizes the SNR at the receive end. To see this, assume that amplifying a particular signal to 50 dB and applying it to telephone wiring creates EMF radiation just below the legal limits. Assume further that a given transmission path imparts 30 dB of attenuation and that the noise level at the input to the amplifier and at the input to the receiver at the end of the path is 5 dB mV. Assuming the signal encounters the amplifier after 25 dB of attenuation, the SNR at the amplifier input will be 20 dB. Because the amplifier processes signal and noise in parallel, and both signal and noise attenuate in parallel during transmission to the receiver, the SNR will be no higher than 20 dB at the input to the receiver.

Now assume that the amplifier is encountered after only 5 dB of attenuation. The signal level at the amplifier output will still be 50 dB mV but 25 dB of attenuation is encountered in transmission to the receiver, making the signal level 25 dB mV at that point. Because the noise will again be at its 5 dB mV minimum, the SNR will be 20 dB.

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By contrast, if amplification is applied after 15 dB of attenuation, which is the "midpoint", the signal level at both the amplifier input and the receiver input will be 35 dB mV, and the SNR at the receiver will be 30 dB.

Often, signal loss is divided approximately evenly between the attenuation of transmission on extended pairs 405, and the attenuation cause by the splits in signal energy that occur at the junctions of local networks 411. This is an important reason why local network interfaces 404 are useful. When transceiver/switch 400 is located on a telephone pole, for example, the initial signal level is often sufficient to provide a good SNR at each of local network interfaces 404, and the received signal is then boosted to transmit across local networks 411 to present at a receiver 419 with adequate SNR.

The wiring configuration of most apartment buildings offers a similar opportunity. Specifically, amplification devices can be placed in the wiring closets to boost the level of the signals transmitting in both directions between transceiver/switch 400 and local networks 411. As such, this booster serves the function of local network interfaces 404, being located in a wiring closet instead of being mounted on the an external wall of a house.

A major advantage of this location is that one electronic device can provide the hardware for several local networks 411 at the same time. This provides hardware, installation, and maintenance economies. (A disadvantage is that the wires from several local networks 411 are still close enough to make crosstalk an issue.)

FIG. 14 shows a design for wiring closet booster 504, which houses local network interfaces 404a, 404b, and 404c. A situation where local interfaces 404a–404c can be co-located can occur, for example, when the five local networks 411 are located in different units in an apartment building, and the units of local networks 411a, 411b, and 411c are located on the same floor and served by the same wiring closet.

Only the details of local network interface 404b are shown. Furthermore, it is seen that the signal processing in each of 404a, 404b, and 404c is independent and that they operate on different signals. It will be appreciated, however, that local interfaces 404a–404c can be serviced by the same power supply. This is one of the hardware economies of including them in the same housing.

The embodiment of local network interface 404b shown in FIG. 14 is similar to that shown in FIG. 10. The only differences are that some of the components are replaced by components that represent more specific embodiments. Specifically, coupling network 437a, telephone signal processing section 470a, and local processor 439a, represent coupling network 437, telephone signal processing section 470, and local processor 439. Internal to local processor 439a, import processor 440a represents import processor 440, and export processor 441a represents export processor 441.

According to the descriptions provided above, of the components that are shown in FIG. 14, telephone signals transmit at baseband through telephone signal processing section 470a between extended pair 405b and network 411b. Also, non-telephone RF signals from transceiver/switch 400 transmit through coupling network 437a, filter 438, import processor 440a, filter 460, coupling network 449, and filter 463 onto local network 411b. In the opposite direction, non-telephone RF signals transmit from local network 411b through filter 463, coupling network 449, filter 461, export processor 441a, filter 445, coupling network 437a and across extended pair 405b to transceiver/switch 400. Filters

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460 and 448 are shown with dashed lines because these filters may not be necessary if the directional multiplexing in coupling networks 437a and 449 provides strong isolation of transmission paths.

Important to booster 504 are import processor 440a and export processor 441a. These components amplify their input signals, outputting the individual signals in the various frequency bands at the energy level at which the radiated energy they create is just below the legal limit. This maximizes the SNR of non-telephone signals received from local networks 411a–411c, and the SNR of non-telephone signals received from transceiver/switch 400.

There may be applications for allowing for communication between local networks 411 by transmitting signals between the ones of local network interfaces 404 located together within wiring closet booster 504. This function is contemplated within this disclosure but technology to achieve it is not specifically described.

M. Transmission of Compressed Digital Video Signals (FIG. 15)

As described above, NTSC video signals can be digitized and compressed, without losing information content, so that the resultant digital bitstream has a data rate that is slow enough to be expressed as an analog waveform in a remarkably narrow channel. Specifically, the resulting waveform can be confined within channels less than 4 Mhz wide, and can be accurately received with SNRs less than 30 dB. Thus, video signals encoded in this manner are more amenable to transmission within the system disclosed herein than even FM video signals.

Transmission of digital signals between transceiver/switch 400 and local networks 411 was described above. Conceptually, these components are sufficient to transmit a digital bitstream representing a video signal. That description, however, does not include the digitization and compression components that may be used to convert the signal at the transmit end, and does not include the elements that may be used to reconstruct the signal so that it can be viewed at the receive end. Those components and the manner in which they coordinate with the other elements of this communication system are the subject of this section.

As mentioned earlier, electronics that digitize and compress analog NTSC video signals in real time are relatively expensive, as are the electronics that perform the subsequent reconstruction of the analog signal from the digital bitstream. The expense typically increases dramatically with the compression ratio, so that a compression process that allows the resulting bitstream to be expressed in bandwidths less than 4 Mhz and minimum SNRs less than 30 dB is relatively complex and costly.

As a result, transmission of compressed digital video is comparatively less complex and expensive if the video signals on communication line 402 are already in this form (i.e. an analog waveform representing a compressed digital bitstream) when they are applied to transceiver/switch 400. Such a system can be very economical in distribution of cable TV, where a group of video signals is to be made available for selection by a large number of subscribers. The economy arises from the fact that this single group of signals need be digitized and compressed only once—at the head-end of the cable system.

Referring to FIG. 5a, signal distribution subsystem 403a can select digitized video signals from communication line 402 and to feed them onto extended pairs 405. Indeed, transmission of these signals is, as a practical matter, no different than transmission of the digital signals described above.

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Following is an example. Assume communication line 402 is a single coaxial cable that provides 60 channels of digital video signals, confined within adjacent 4 Mhz bands that extend between 200 Mhz and 440 Mhz. These signals are received by interface 409 and transmitted directly to splitter 426′ in subsystem 403a. (I.e., interface 409 does not block shift or otherwise process these signals.) Splitter 426′ feeds the signals to each demodulator 426. Under control of master controller 415, demodulator 426a basebands the channel between 204 MHz and 208 Mhz, and transmits it to switch 462a, which in turn applies this basebanded signal to modulator 410d. Modulator 410d remodulates the signal, using AM, to the frequencies between 12 MHz–16 Mhz. Thus, the effect of this modulation/demodulation is simply to shift the signal to the new band. The output of modulator 410d is fed to switch 401, and that device directs the signal through signal separator 413b onto extended pair 405b.

If subsystem 403c (FIG. 5c) is provided instead of subsystem 403a, the processing and signal flow work similarly. In this case, RF processors 485 convert the selected signal to the channel between 12 MHz and 16 Mhz.

If local network interfaces 404 are provided, they can receive the digital signals from extended pairs 405, amplify them, convert them in frequency, and retransmit them onto local networks 411, all using the techniques described above. If local network interfaces 404 are not provided, these are signals transmitted directly onto local networks 411 confined within a channel whose bandwidth is the same as the original channel confining the digital signal.

Referring to FIG. 15, the digital signals transmitted onto local networks 411 are received by digital 20 video receiver 505. This device is not shown connected to any local network in FIGS. 1a or 1b. It is shown connected to TV 492b and local network 411b, however, and it coordinates with the rest of the system components in the same manner as video receiver 419b.

In a general sense, this receiver is identical to television transceiver 15, shown in FIG. 2 in the parent application. Specifically, video processing circuitry 506 corresponds to RF converter 19, coupling network 513 corresponds to coupling network 18, and control signal processing circuitry 514 corresponds to control signal processing circuitry 17.

Video signals from local network 411b are blocked from telephone device 414b by the low pass filter and are directed by coupling network 513 to video processing circuitry 506. Coupling network 513 and circuitry 514 function identically to their corresponding components in transceiver 15.

Like RF converter 19, video processing circuitry 506 converts the received video signal to a form that is tunable by ordinary televisions. The following process is used, however, because the signal is an analog representation of a bitstream that represents a video signal.

In the first stage of the processing, the video signal is basebanded in the ordinary fashion. The elements in FIG. 15 show the steps of this process: shifting to an intermediate channel by mixing with a local oscillator, filtering of the intermediate channel, and then demodulation. Using the example above, the 16 MHz–20 Mhz signal may be shifted to the 40 MHz–44 Mhz band, filtered, and then detected, resulting in a basebanded signal. Alternatively, the "intermediate channel" can be fixed at 16 MHz–20 Mhz, removing the need for frequency shifting.

In the second stage, the basebanded analog signal is converted to a digital bitstream, which is decompressed in real time. In the classic procedure, a digital process reads the bitstream and uses that data to fill out a matrix of storage locations representing the pixels of the image. This matrix is

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refreshed 60 times a second, the "refresh rate" of NTSC video. The actual NTSC signal is then created by scanning across the storage locations (conceptually, the pixels of a frame) just as a video camera creates a picture by scanning across a photoconductive grid.

The third stage is the modulation stage. The newly recreated NTSC signal is passed to this stage at baseband. It is mixed using a local oscillator, creating an AM NTSC signal in the ordinary manner. This signal is passed to TV 492b.

Note that channel selection still takes place in the ordinary manner. Using the examples above, IR transmitter 493b issues infrared signals that are detected by the IR sensitive diode of receiver 505. These signals are converted by circuitry 514 to, for example, a 0.5 Mhz signal centered at 23 Mhz. (This is the frequency used for communication of control signals in FIG. 8.) These signals are applied to local network 411b and transmit to master controller 415 using the circuitry and signals paths described in the sections above. In response to this signal, controller 415 can instruct demodulator 426a to select a different channel from among the 60 available between 200 MHz–440 Mhz on communication line 402.

When FM communication techniques are not sufficient due to the length of extended pairs 404 and the nature of local networks 411, communication of the video signals in compressed digital form is indicated, even if signals are provided by communication line 402 in analog form. In that event, digitization and compression are performed prior to transmission onto extended pairs 405. This conversion can take place in signal distribution subsystem 403a.

Referring to FIG. 5a, the desired result can be achieved by replacing one of modulators 410 for every digital video signal provided by processor 418. The new processors 410 are similar in that they receive a basebanded video signal and output an analog waveform confined within a particular channel at a signal level that creates radio energy just below the legal limits. The difference is that the waveform now represents a compressed digital bitstream, which in turn represents the original NTSC signal.

The above description includes the components used to transmit digital video signals from transceiver/switch 400 to local networks 411. Similar techniques can be used for transmission in the opposite direction but are not specifically described herein.

N. Transmission of Video Signals Across Computer Communication Networks with "Star" Configurations (FIG. 16)

As described in the summary section, in many office buildings, the telephone wiring is not the only network of twisted pair wiring that extends to each office and converges at a common point. Over the past several years, common communication networks that connect personal computers, known as Local Area Networks or LANs, have begun to use twisted pair wiring for their conductive paths. In the typical configuration, a digital electronic device serves as the "hub" for such a system, and a separate twisted pair wire connects from the hub to each of the computer nodes in a "star configuration". In this section, the techniques described for communication across wiring networks that conduct telephone communication are extended to provide the same communication capabilities across computer networks that used twisted pair wiring and adopt such a "star" configuration.

To illustrate such a star configuration, one need only change a few of the elements of the setup shown in FIG. 1b. The result is shown in FIG. 16. One change is that PBX 500 is replaced by communications hub 519, which is the digital

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device that serves as the "nerve center" of the communication system. Another change is that line 475' is not required. Finally, telephone devices 514 are replaced by computers 518, which are the devices that communicate across the network using the concepts described herein.

The only fundamental change required when the communication medium is provided by this new system is that the lower bound on the frequencies available for communication with line 402 (or for communication between the RF transmitters, receivers, and transceivers connected to the local networks) will be higher. Specifically, the lower bound must be above the highest frequency used for communication between computers 518 and hub 519. For example, when the computer communication system follows the 10 Base T standard, which is the most popular standard for local area networks that use twisted pair wires, the computers communicate at frequencies up to 15 Mhz, and the lower bound must be above that above that frequency.

Following are the electronic changes that should be made to provide all of the functions discussed above:

1) The low pass filters connecting between computers 518 and local area networks 511 must have higher cutoff values. Specifically, the cutoff frequency must be high enough to pass the communication signals transmitting between hub 519 and computers 518.

2) The cutoff frequency of low pass filters 474 (FIG. 2) is increased in a similar fashion. The cutoff frequency of low pass filter 442 should also be increased if local network interfaces 404 are provided.

3) The cutoff frequency of hi-pass filter 451, which is part of signal separators 413 shown in FIG. 9a, should be raised above the highest frequency used by computers 518. Thus, this filter will not pass some of the lower frequency signals it passed previously.

4) The spectral distributions shown in FIG. 3 will not be available if they overlap the frequencies used by the computer signals. Higher frequencies can be used.

5) The minimum frequencies suggested in Section C will also not be available if they overlap the frequencies used by the computer signals.

O. Preventing Unintended Reception and Control Signal Confusion

The problem of energy from one extended pair crossing over to a second pair and causing interference with video signals was described above. One proposed solution was to lower the susceptibility to interference by encoding the signals using frequency modulation. Susceptibility would be reduced because of the low "capture ratios" exhibited by FM receivers.

A second problem is caused by energy crossover, however, that may not be adequately addressed by low "capture-ratios." This problem is one that arises when the second pair is not being used to conduct video signals, and the energy crossing onto that wire is sufficient to allow reception of the signal on the local network to which the second extended pair connects. A related problem is where the control signal transmitted onto one extended pair crosses over to a second pair, causing transceiver/switch 400 to react as if a control signal had genuinely been applied to the second pair.

The proposed solution is to ensure that a signal always transmits onto each of the extended pairs in a bundle within each of the channels used for transmission, whether or not a genuine signal is intended for conduction at that channel. A convenient way of doing this is to transmit the unmodulated carrier for every channel onto those wire pairs that are

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not intended to conduct a signal at that channel. Similarly, continuously transmitting the carrier of the control signal can solve the related problem of control signal "confusion."

Following is an example using the signals listed in FIG. 8. Note that video signal V is transmitted onto extended pair 405a between the frequencies of 7 Mhz and 22 Mhz. This signal is created by frequency modulating a carrier of 14.5 Mhz, and is received by local network interface 494a and relayed onto network 411a. Assuming that signal V was not transmitted onto extended pairs 405b and 405c but crosses over onto pairs 405b and 405c, there would be a danger that the crossover signal V could be received by local network interfaces 404b and 404c. (FIG. 8 shows that signal V is indeed transmitted to networks 411b and 411c between 1-6 Mhz, but we will ignore that fact for the purposes of this example.) The proposed solution is to transmit the unmodulated 14.5 Mhz carrier onto extended pairs 405b and 405c, lowering the SNR of the crossover video signal V received by local network interfaces 404b and 404c below acceptable levels.

Continuing the example, users at network 411a may issue infrared control signals that are transmitted over extended pair 405a by modulating a carrier with a fundamental frequency of 23 Mhz. Theoretically, these signals can crossover onto extended pairs 405b and 405c, incorrectly exciting control signal processor 420 in transceiver/switch 400. The proposed solution is to have video receivers 419b and 419c continuously feed their 23 Mhz carrier, unmodulated, onto networks 411b and 411c (from which they are relayed onto extended pairs 405b and 405c by local network interfaces 404b and 494c.)

Still other embodiments are within the scope of the following claims.

What is claimed is:

1. A system for communicating information between an external source of information and destinations of information each at a different one of a plurality of residences over a telephone wiring network used for passing telephone signals in a telephone voice band between telephone devices at the residences and a telephone exchange, comprising:

    a plurality of transceivers, each located at a different one of the residences and coupled to a destination of information at said residence;

    a signal interface located on the telephone wiring network between the telephone exchange and each of the residences;

    a plurality of separate conductive paths, each coupling the signal interface and a different one of the plurality of transceivers and providing at least part of a path for telephone signals in the voice band between the telephone exchange and one or more of the telephone devices at the same residence as said transceiver, wherein each of said separate conductive paths exceeds 1000 feet in length;

    at each of the residences at which one of the transceivers is located, a branch conductive path coupled at a location separated from said transceiver to the separate conductive path from the signal interface to said transceiver, said branch conductive path providing at least part of the path for telephone signals in the voice band between the telephone exchange and a telephone device at said residence; and

for each branch conductive path, a filter coupled between the branch conductive path and the corresponding telephone device;

wherein each transceiver includes circuitry for communicating with the signal interface in a high frequency band of frequencies above the highest frequency of the telephone voice band over the separate conductive path coupling said transceiver with the signal interface;

each of the filters that is coupled to a branch conductive path is configured for preventing signals in the high band of frequencies from passing to the telephone device coupled to said branch conductive path; and

the signal interface includes circuitry for receiving a plurality of external signals encoding information streams from the external source of information, circuitry for transmitting over the telephone wiring network to the transceivers a plurality of internal signals in the high frequency band encoding the information streams, and circuitry for limiting transmission of signals in the high frequency band from the telephone wiring network to the telephone exchange and for passing signals in the telephone frequency band between the telephone wiring network and the telephone exchange.

2. The system of claim 1 wherein each external signal includes a corresponding external data signal encoding a data stream and each internal signal includes a corresponding internal data signal encoding said data stream, and wherein the circuitry at each transceiver for communicating with the signal interface further includes circuitry for receiving the corresponding internal data signal and presenting said data stream to the destination of information.

3. The system of claim 1 wherein the circuitry at each transceiver for communicating with the signal interface includes circuitry for transmitting a control signal in the high frequency band to the signal interface.

4. The system of claim 1 wherein each of the filters that is coupled to a branch conductive path reflects substantially all of the energy in the high frequency band transmitting from said branch path, and the communication system includes circuitry for mitigating the effect of reflections so that said transceivers correctly receive internal signals from the signal interface.

5. The system of claim 4 wherein the circuitry for mitigating the effect of reflections includes circuitry connected to a branch conductive path that terminates high-frequency energy flowing along that path.

6. The system of claim 4 wherein the circuitry for mitigating the effect of reflections includes cooperative circuitry at the signal interface and at each transceiver.

7. The system of claim 4 wherein each of the transceivers includes signal processing circuitry for mitigating distortions of an internal signal introduced during transmission from the signal interface.

8. The system of claim 1 wherein the signal interface includes circuitry for selecting a subset of zero or more transceivers for receipt of each of the information streams accepted from the external source of information.

9. The system of claim 1 further comprising an RJ-11 jack coupled between one of the branch conductive paths and filter connected to said branch.

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